RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #12

Analysis of GPS Data, in Regard to
Extended Squitter Transmission Rate on the Airport Surface

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SUMMARY

When an aircraft is on the airport surface, the transmission rate for Extended Squitters changes according to whether the aircraft is stationary of moving. The changes are controlled by a threshold, whose value is specified to be 10 meters in DO-260. Currently WG-3 is considering a change to this threshold in order to improve the response time for situations in which an aircraft is stationary briefly, as for example when waiting to cross an active runway, then begins to move again. To investigate this issue, WG-3 is collecting GPS data and processing it using the algorithm specified in DO-260.

An initial analysis of this kind was done in February and March of this year, using GPS data recorded at the Technical Center. In discussing these results, we came to realize that the initial data was acquired from a surveying GPS receiver, and we decided to determine whether the accuracy behavior would be different for an avionics GPS receiver. Therefore another data-acquisition was undertaken at the Tech. Center.

The results show that the accuracy behavior is quite different for the avionics receiver. Errors are larger and more variable. Nevertheless, the results, which are presented in this paper, show that the switching threshold can be reduced significantly. This paper addresses action item 10-5.

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INTRODUCTION

A proposed change to the ADS-B MASPS questions the current switching standard for Extended Squitter transmission rate when an aircraft is on the airport surface. The proposal is to require transmissions at the high rate at all times, even when an aircraft is stationary for a long period of time.

Currently the transmission rate on the airport can switch between high rate, which is 2 per second, and low rate, which is one transmission per 5 seconds. This design is based on the fact that normally the number of aircraft on the movement area of an airport is kept relatively low by ATC procedures, in order to minimize fuel consumption prior to takeoff. On the other hand, in rare situations a very much larger number of aircraft may be in the movement area. This can happen because of bad weather at other airports, causing reduction of takeoffs, while landings continue. In order to make room at the gates for arriving aircraft, it is necessary to move many of the aircraft that are loaded and ready to take off, but cannot take off, to stationary locations on the movement area.

The current Extended Squitter design for switching between high rate and low rate is standardized in the MOPS (DO-260). High rate transmissions are considered to be the normal condition. The algorithm for switching to low rate and back to high rate can be summarized as follows.

> <u>Switch from high rate to low rate</u> when the lat-lon position has not changed by more than 10 meters in a 30 second period.

> <u>Switch from low rate to high rate</u> when the lat-lon position has changed by 10 meters or more since the location when the low rate began

The objection to this design is motivated by the consideration of an aircraft that is stationary for a relatively short time before crossing an active runway. When the aircraft begins to move again, it is important for the receiving system to detect the event promptly. This issue has been discussed at several recent meetings of WG-3. One way of dealing with the issue is to reduce the switching threshold from the current value, 10 meters.

GPS DATA

Actions are being taken by WG-3 to investigate such a change. Carl Jezierski and Stu Searight arranged for GPS position measurements to be recorded for a fixed receiving location at the Tech Center. They made GPS recordings on several occasions. The first recordings were made from a GPS receiver intended for surveying applications. The processed results were presented at the WG-3 meeting in March 2002. Subsequent discussions focused on the realization that avionics-grade receivers might have different accuracy behavior, so another data acquisition was performed. The new data was recorded at Tech. Center on 28-29 March 2002, using a Collins GNLU-930 receiver.

During this time period, the GPS system is being operated with SA off, which is currently the normal condition, and GPS receiver was not using WAAS. Two datasets were recorded, with and without LAAS. The receiver was operated on a bench, using a rooftop antenna.

ANALYSIS

To analyze this data, we applied the transmission rate switching algorithm to the lat-lon positions in the data. We began by using a threshold value of 10 meters. Then we changed the threshold to 9 meters, and continued for each integer value down to 1 meter. In each case, the results indicate that the initial high rate would soon switch to low rate (because the receiver is stationary). Thereafter, occasional switching back to high rate would be triggered by lat-lon variations, and subsequently the rate would return to low rate.

RESULTS

The dataset consists of 84.6 hours of data. We ran the entire dataset in this manner, and summarized the results in the form of the average transmission rate for each value of threshold. The results are given in Table I.

Table I. Transmission rate as affected by switching threshold.

THRESHOLD	AVERAGE TRANSMISSION RATE	NUMBER OF SWITCHES	AVERAGE RATE OF SWITCHING
(meters)	(per sec.)	(in 84.6 hours)	(per hour)
10	0.20	11	0.1
9	0.20	21	0.2
8	0.21	41	0.5
7	0.22	84	1.0
6	0.23	156	1.8
5	0.27	331	3.9
4	0.34	634	7.5
3	0.44	1032	12
2	0.60	1618	19
1	0.88	2378	28

The two columns on the right give the rate of switching from low rate to high rate.

These results are plotted in Figures 1, where the average rates can be compared against the high-rate and low-rate values. The results indicate that if the threshold is 10 meters, the average rate is almost exactly the low-rate value, which means that the occasional switching to high rate has no significant effect. If the threshold is reduced to 5 meters, this is still approximately true. In other words, whereas a reduction in threshold from 10 to 5 meters would improve response time, it would cause little degradation in the average transmission rate.

Based on these results, I would recommend changing the switching threshold to 3 meters. This would provide a rapid response time when an aircraft begins to move after being stationary and would cause only a small increase in the average transmission rate.
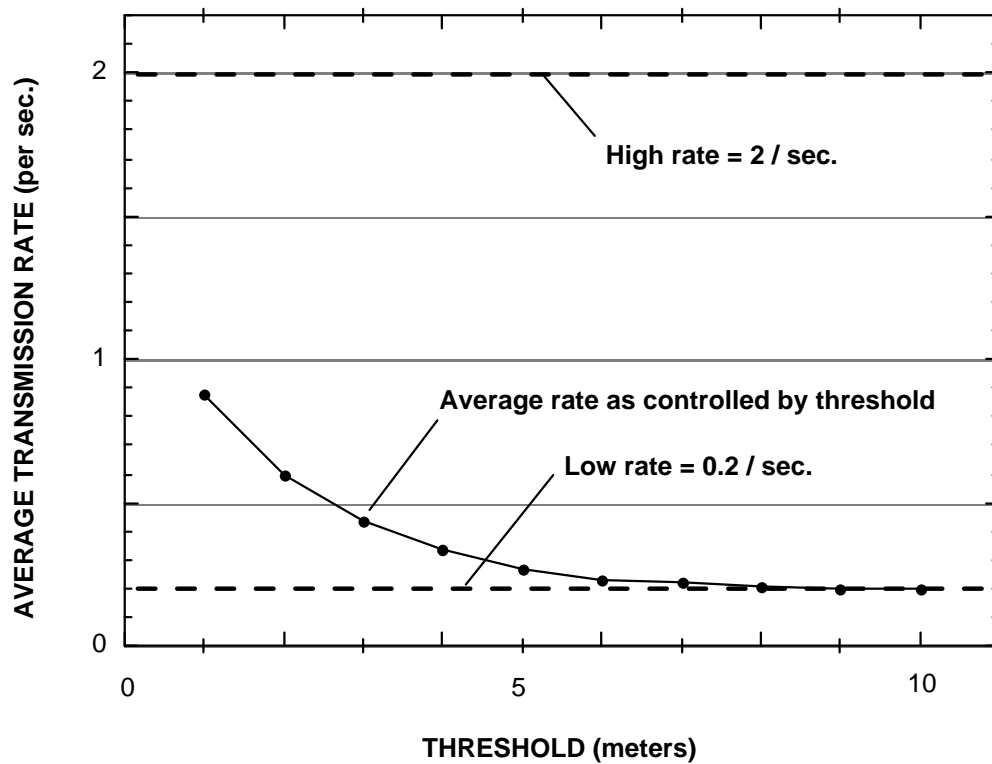
Figure 1. Average transmission rate as controlled by the switching threshold.

RECEIVER USING LAAS

As mentioned above, the Tech Center also recorded some GPS data in LAAS mode. This was the same model of GPS receiver, although not the same unit. The analysis was done in the same manner, producing the results given in Table II.

Table II. Results when the receiver is operated using LAAS.

THRESHOLD	AVERAGE TRANSMISSION RATE	NUMBER OF SWITCHES	AVERAGE RATE OF SWITCHING
(meters)	(per sec.)	(in 84.6 hours)	(per hour)
10	0.20	2	0.0
9	0.20	3	0.0
8	0.20	3	0.0
7	0.20	7	0.1
6	0.20	12	0.2
5	0.20	19	0.3
4	0.21	24	0.4
3	0.22	54	0.8
2	0.25	139	2.1
1	0.36	381	5.8

COMPARISON WITH THE SURVEYING RECEIVER

When comparing the above results with the results for a GPS surveying receiver (WP-10-07), it becomes clear that the surveying receiver behaves differently from an avionics receiver. Figures 2, 3, and 4 have been prepared to directly show the accuracy behavior of the three kinds of data analyzed. Evidently the receiver intended for surveying applies a major form of averaging which would not be appropriate for a moving aircraft.

Figure 4, which applies when LAAS is being used, shows clearly that the GPS accuracy is significantly improved. This is reflected in the improved performance seen above in Table II, relative to the non-LAAS performance shown in Table I.
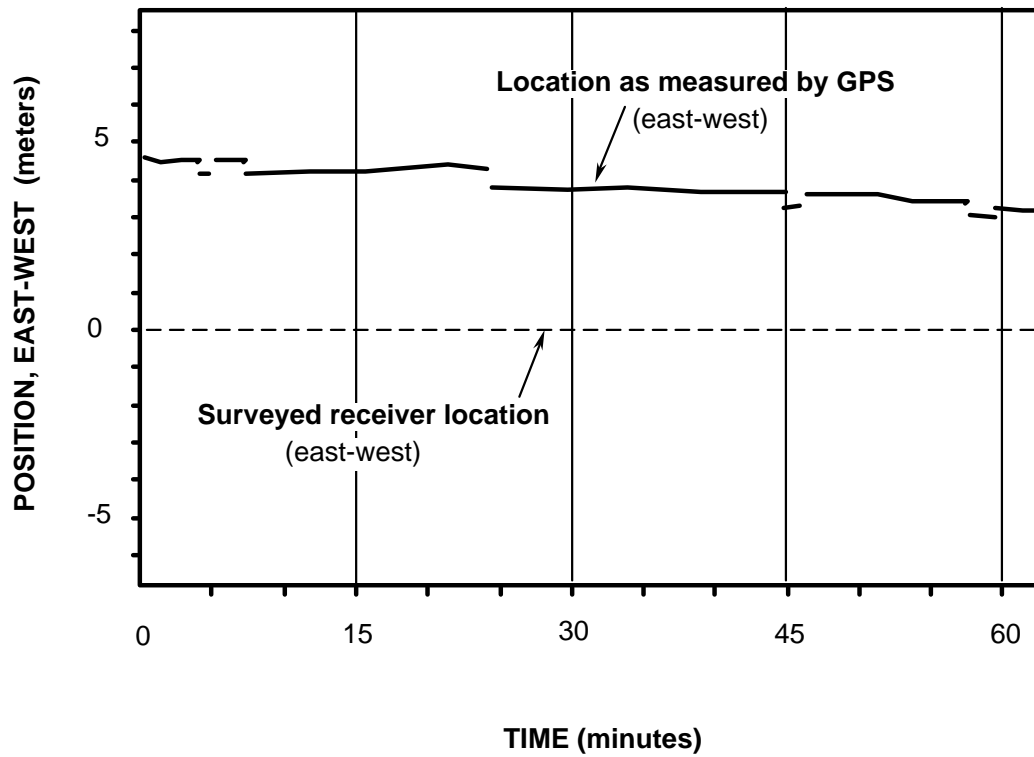
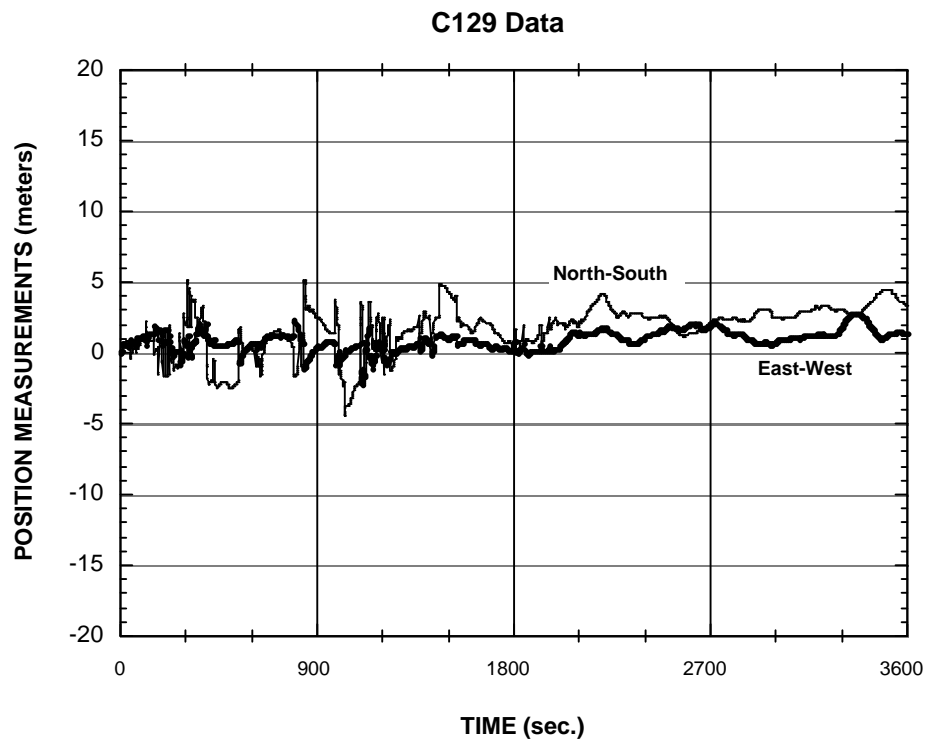Figure 2. Typical GPS fluctuations — Surveying Receiver.

C129 Data

Figure 3. Typical GPS fluctuations — Avionics Receiver (not LAAS).
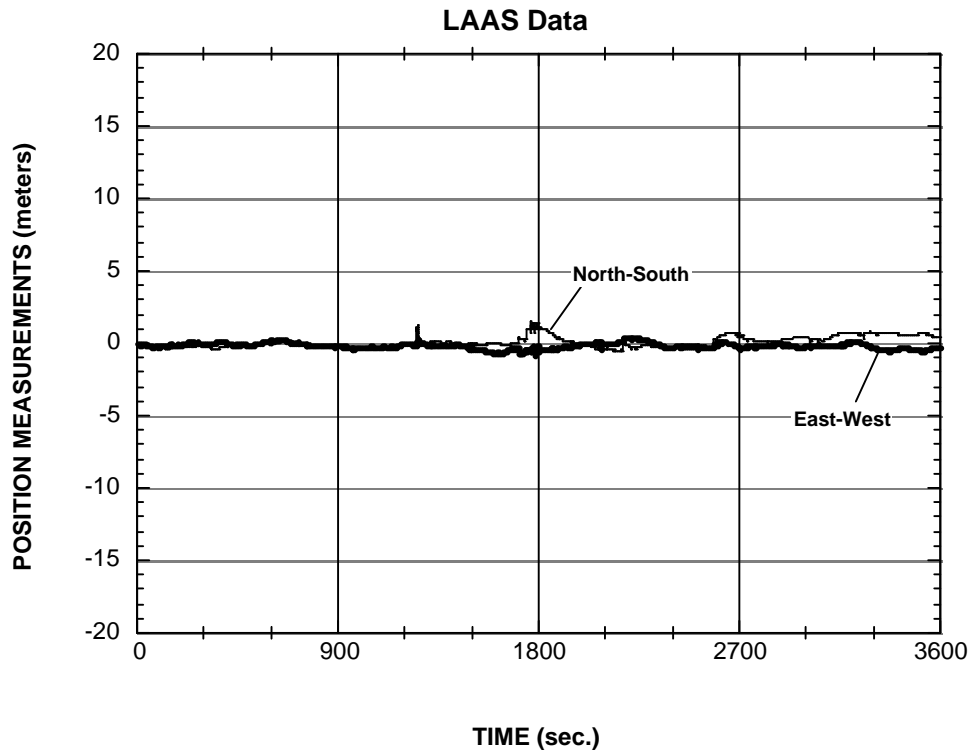
LAAS Data

Figure 4. Typical GPS fluctuation — Avionics Receiver Using LAAS.

CONCLUSIONS

(1) The results show that a GPS receiver intended for surveying behaves differently from an avionics receiver. It was important to extend this study to an actual avionics receiver.

(2) The results confirm the expectation that the threshold can be reduced substantially below 10 meters. This will improve response time when an aircraft is beginning to move after being stationary, and yet the average transmission rate will still be much lower than the high rate.

(3) Based on these results, I would recommend setting the switching threshold equal to 3 meters. This would provide a rapid response time when an aircraft that was stationary begins to move and would cause only a small increase in the average transmission rate.

(4) Conceivably, the threshold could be set still lower when LAAS is being used. In this case, the threshold could be set to 1 meter. This does not seem to be necessary, but might be kept in mind as an option, or as a refinement for use in the future.